# 10. Simulation Games for Engaging Students When Teaching Operations and Supply Chain Management to Students: Using the QpQ Simulation Game as Example

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# Abstract

In simulation games, a form of generative learning, students play an active role in their own learning process, seen as key to gaining and retaining knowledge. This chapter presents its advantages, different takes on how to achieve desired learning outcomes and what efforts need to be undertaken by staff in the domain of operations and supply chain management. The points raised are showcased through the QpQ Simulation Game that replicates departments and processes at a manufacturing company. Three deliveries using different settings show that students’ knowledge and understanding of key concepts for operations management concepts refined, decision-making skills were enhanced, teamwork was boosted and a deeper understanding of the complex and dynamic processes for manufacturing companies was gained. Such outcomes are typical for using simulation games in teaching operations and supply chain management. At the end of the chapter, key points capture how to stimulate generative learning and increase student engagement, and reflect on when to choose a simulation game, which selection criteria could be considered and what are lessons learnt.

**Keywords**: active learning, operations management, simulation games, supply chain management, systems thinking

# Objectives of Chapter

This chapter

* sets out what the purposes of simulation games are as part of pedagogy for teaching operations management, its theories, principles, concepts, methods and practices;
* highlights differences between online simulation games (simulators) and physical simulation games;
* provides an overview of advantages and challenges for using simulation games when teaching operations management;
* details how simulation games can be integrated into teaching plans for operations management;
* presents the QpQ Simulation Game as an example of using and integrating a simulation game in teaching.

# Introduction

Simulation games have been used for years in higher education. One of the most famous games for simulating supply chains is the ‘Beer Simulation Game’, which was developed by MIT in the 1960s based on Forrester’s (1961: 22, 139) modelling of an industrial system. Its main purpose was to simplify the complex principles of supply chains and present them to students in an easy way for them to understand key concepts. Since then, many studies (e.g., Chang et al., 2009; Pasin and Giroux, 2011) have discussed the use of simulation games and the way they enhance participants’ understanding of processes and related principles. Although simulation games have been used in teaching various courses in nursing, engineering and management (Pasin and Giroux, 2011: 1240), their application does not stop there. Many of these simulation games have also been used to teach practitioners. For instance, according to Lewis and Maylor (2007: 135), some companies have integrated simulation games into their interview and selection processes in order to test candidates on their understanding of the industry environment. Another example is the learning laboratory set up for the electronics industry in Finland described by Haapasalo and Hyvönen (2001). And Smeds (1997) describes how simulation games were used in two cases for learning about and implementing business process re-engineering. Notwithstanding the broader reach of simulation games, one of the main purposes for the use of simulation games is to improve students’ conceptual knowledge and skills in classroom settings, which is a necessity for management teaching in general, according to Elmuti (2004: 440). To this purpose, academics tend to develop and use simulation games in courses on operations and supply chain management (among others) to facilitate understanding of relevant concepts and encourage the participation of students through active learning; this is highlighted by Chang et al. (2009: 1252) when presenting a game oriented at supply chains, and Chwif and Barretto (2003: 1999) when discussing three games in operations management. This means that learning supported by simulations games for students in operations and supply chain management is student-centred and can enrich learning.

In addition to being student-centred, simulation games may also overcome some challenges for teaching operations and supply chain management. As Costantino et al. (2012: 3481) state, students often have limited direct experience with operations and supply chain management, making teaching somewhat cumbersome. Moreover, this domain has a complexity that is likely difficult to transmit during traditional lectures and tutorials. The complexity of production and supply systems includes the different actors and departments involved in decision making and processing orders, multiple processes such as primary processes (supply and production) and information (orders and control process), and multiple criteria (productivity, lead times, quality, flexibility, etc). Although other measures for students gaining insight and experience could be considered such as industrial placement and guest lectures the use of simulation games is an attractive means to let students get to grips with what operations and supply chain management covers and what its essentials are during the provision of teaching.

To achieve this active learning and better understand the concepts of operations and supply chain management, this chapter will discuss how simulation games can be integrated into a pedagogy suitable to the domain. It will look at types of learning associated with simulation games and how this can be integrated into a teaching plan, with particular focus on higher education. Furthermore, this chapter presents the design, delivery and evaluation of the QpQ Simulation Game for students participating in teaching on operations management as an example of how it was integrated into pedagogy. The emphases of this chapter are looking at the impact that simulation games have on students’ learning to understand basic principles of operations and supply chain management in simulated real-life settings and their integration into pedagogy accounting for their different contexts.

The chapter is organised as follows. First, in Section 2, what simulation games are leads to discussing types of games, their advantages and disadvantages, and how they fit with teaching plans. Next, in Section 3 the QpQ Simulation Game is introduced, its deliveries presented and evaluated. Section 4 concludes with key points for the use of simulation games when teaching operations and supply chain management.

# Simulation Games and Learning

Before going into the background of simulation games, it is important to note that there is some ambiguity about what a simulation game is, but this also leads to what it is about. Despite the games’ long existence, the academic literature has not come to an agreement as to how a simulation game is defined and many studies use different concepts for describing them, leading to confusion (Clarke, 2009: 448). Undoubtedly, one of the main elements in defining simulation games is related to the learning method. Pasin and Giroux (2011: 1241) define simulation games as ‘challenging interactive pedagogical exercises, wherein learners must use their knowledge and skills to attain specific goals, played within an artificial reproduction of a relevant reality’. In this definition, the study clearly shows the important link to learning. Very differently, Jones (1980: 12) denotes a simulation game as ‘essentially a case study, but with the participants on the inside’; this definition is followed by Clarke (2009: 448) and Thavikulwat (2004: 243). However, as already mentioned, it would be false to believe that simulation games have only been used for students’ learning; for example, van der Zee and Slomp (2009: 20) clarify that simulation games can assist workers to find the best solution for a specific problem. Without wading further into definitions, the cited descriptions demonstrate the points for simulation games that will come back in this chapter: active learning by participants, obtaining knowledge and skills, gaining experience by mimicking reality and essentially being a case study.

## Brief Background to Development of Simulation Games

To better understand these points, it is best to go back to how simulation games found their way into teaching. The use of simulation games in education was preceded by political and war games, according to Lewis and Maylor (2007: 135). The coming together of strategic and operational games by defence institutes, such as the RAND Corporation, the emergence of the domains industrial engineering and management, and the development of computers led to the introduction of simulation games in education. When simulation games for educational reasons started in the 1950s for the discipline of business and management studies, some were paper-based (or physical games) and others supported by computers. An instance of a simulation game supported by computers is the Top Management Decision Simulation developed in 1956 by the American Management Association (Pasin and Giroux, 2011: 1242). An example of physical is the Beer Simulation Game, mentioned in the introduction, which is paper-based with a banner or gameboard. However, at the present time most games involve information and communication technologies (ICT) or are dependent on it (Pasin and Giroux, 2011: 135–136), and so, is the Beer Simulation Game also played online (e.g., Jeong and Hong, 2011) to demonstrate the point. And it has become more common to use simulation games also for teaching operations and supply chain management.

Moreover, simulation games have been developed for a broad range of topics in operations and supply chain management. They cover games for specific topics such as calculating inventory to simulation of production systems. An instance of the first are the eight games presented by Ammar and Wright (1999), each covering a specific topic and principles such as balancing production lines and quality control. On the other side of the spectrum, Haapasalo and Hyvönen (2001) describe a near real-life simulation game for the electronics industry. This broad range also indicates that a wide variety of simulation games has been developed and used, therefore educators can select games that suit learning objectives.

## What Types of Simulation Games

Alongside the distinction between physical simulation games and those based on ICT, the games can be categorised into competitive and experimental games. A competitive game involves teams competing to achieve objectives (Lewis and Maylor, 2007: 136). This can be either preset objectives or competing for the same resource; the original Top Management Decision Simulation is an example of the latter, as a limited number of teams compete with products in the same market. Another simulation game in point is the popular Littlefield Technologies, described by Roeder and Miyaoka (2015) and others. In this game, teams compete for the most on-hand cash at the end of the simulation (Roeder and Miyaoka, 2015: 3483). And the Hunger Chain, developed and described by Song et al. (2021), explores the impact of product shortages and supply chains by using game theory. Experimental games (Lewis and Maylor, 2007: 136) are about figuring out solutions to problems and considering alternatives. An example is the balancing of a production line for airplanes, described in Ammar and Wright (1999: 186–187). Another example is the game derived from set-based concurrent engineering (Pourabdollahian et al., 2012: 260–261), though more correctly it should have been called Pugh’s controlled convergence method (Salgado and Dekkers, 2018: 913–914), applied to developing an airplane. Often, given the complexity of the domains of operations and supply chain management, experimental games offer students insight into what principles are for the domain and their effects on performance, and in the application of methods and techniques, whereas competitive games add a strong emphasis on comparative performance of student teams.

## Simulation Games for Operations and Supply Chain Management

Similar to simulation games for other educational purposes, using a simulation game for operations and supply chain management aims at supporting students related to the theoretical concepts taught in lectures with a practical representation of reality. The games basically tie knowledge into how it is done in real life, more specifically in industry (Salas et al., 2009: 564–565). For example, Ammar and Wright’s (1999) study mentions eight simple activities that can support students’ understanding of the core concepts of operations management; some of them include making products, such as a game producing chairs and tables, and pricing them. There are also some simulation games that require role play (Pourabdollahian et al., 2012: 260) when they use teams of four students, each student representing a specific component for the design of the airplane. Such role-play games also emphasise interactions between students and social skills. And, then there are games that aim at more comprehensive coverage of concepts relevant to operations and supply chain management. By way of illustration, Chuang (2020) mentions the Supply Chain Game™, which simulates a chemical company with different markets. The broad range of simulation games found in the literature indicates different approaches to teaching. It varies from demonstrating concepts and methods, with calculations for inventory being an illustration, to more holistic games. Thus, when considering simulation games when teaching operations and supply chain management, academic staff must be aware of the advantages and disadvantages when integrating it successfully into a pedagogy related to learning objectives.

## Advantages and Disadvantages

Simulation games offer the benefits of generative learning through experiential learning and increasing student engagement. Generative learning aims at active integration of concepts and new ideas into the learner’s existing schemata and cognition. Its main idea is that, in order to learn with understanding, a learner has to actively construct meaning (Osborne and Wittrock, 1983: 493), which Wittrock (1974: 88–92) based on experiments to demonstrate the difference between generative and reproductive processing. That simulation games stimulate generative learning by students is recognised in the literature. For example, Zantow et al. (2005) describe the relationship conceptually for a strategic management game. Loon et al. (2015) build on Zantow et al. (2005) and evidence the generative learning by students that took place during a strategic management game. However, Osborne and Wittrock’s (1983: 493) model also points to sensory information and sensed experiences; for simulation games, it implies to which degree information was observed and sensed by students. This aspect seems to get less attention when writing about simulation games for business and management studies but plays a vital role. Take, for example, visualisation; this will be different for web-based simulation games versus physical simulation games in terms of sensing the activities in a simulation game going on and the interaction with other students. Another point to consider is student engagement, which is at the core of achievement and learning in higher education (Kahu, 2013). According to Kahu (2013: 766), it consists of affect, cognition and behaviour; all three tie in to learning and well-being. For instance, positive student engagement is reported by Meltzer (2012) for a stock market simulation game. In this sense, results of a systematic literature review by Faisal et al. (2022: 1578791/19–20) confirm that business simulation games offer a broad learning experience, with cognitive gains, social skills and student engagement among them. All this means that whereas generative learning takes centre-stage when looking at simulation games, the other two factors to be considered from an educational perspective are affection and sensory experiences.

This corresponds with the intent of simulation games when used for operations and supply chain management. Given the active involvement of students, they enhance the learning experience of students (Pasin and Giroux, 2011: 1243). Haapasalo and Hyvönen (2001: 270) also stressed the meaning and the benefits of simulation games through learning, more specifically how they boost experiential learning and decision making. Experiential learning theory explains how students can benefit the most by the process of the learning regardless of the outcomes as engaging the student in the learning process can enhance the learning experience (Kolb and Kolb, 2005: 194). In the same vein, Salas et al. (2009: 561) state for simulation games that whereas lecture-based learning and consulting teaching materials is important for gaining facts and knowledge as foundation, the reasoning behind simulation games is to enable in-depth learning through practice and to gain skills such as decision making. This is also supported by Farrell’s (2005: 83) and Li et al.’s (2007: 32) studies, where they found that students perceive simulation games as a more effective and more superior learning tool than lecture-centred approaches. Thus, simulation games enhance the learning experience through both experiential and generative learning, resulting in students gaining knowledge about the application of knowledge gained from lecture-based learning and self-study, and developing practical skills.

Another benefit of using simulation games in classroom settings is that students can develop other skills beyond cognitive and practical knowledge about operations and supply chain management. They allow participants to make mistakes or poor decisions, as the game gives the opportunity to the participant to perform in a risk-free environment (Pasin and Giroux, 2011: 1244). And, during the simulation game as learning experience, practical skills can be gained such as teamwork and oral communication; these kinds of practical skills would be difficult to acquire only through theoretical knowledge (Costantino et al., 2012: 3482). Similarly, Chapman and Martin (1995: 73) remark that such types of learning methods can assist in the development of more effective personal transferable skills such as teamwork, problem solving techniques, and oral and written communication. Consequently, a broad range of practical, social and transferable skills are an additional advantage for students when participating in simulation games.

There are some disadvantages associated with simulation games related to the domains of operations and supply chain management. First, games must be realistic for students to fully engage with them (Pasin and Giroux, 2011: 1247). In this vein, they must be related to the ends that need to be achieved with a simulation game. For the latter, Sparling (2002) describes how the Beer Simulation Game was adapted to go beyond serving as an introduction to phenomena in supply chains. Furthermore, Lewis and Maylor (2007: 145) note that a vast majority of games related to operations management are classified as complex; this argument extends to supply chain management, too. This seems to reflect a belief that such games are better reflections of operational ‘reality’. However, this may come at the expense of learning by students as they might be too concentrated on understanding the game rather than appreciating it as means to gaining in-depth knowledge. And even though simulation games aim at mimicking reality, they are not the real thing; people may react differently when faced with situations in the real world, and this may point to some limitations in practical and transferable skills gained. Another disadvantage is the effort required for developing or adopting games. Nevertheless, Lean et al. (2006: 239) indicate that staff will not be stopped by resource limitations when they think a simulation game is suitable for learning objectives. According to Lean et al. (2006: 231) further barriers to implementation are the amount of class time required for simulations, funding, administrative issues and technical issues. These disadvantages in terms of the design of simulation games and associated efforts to integrate them in teaching has not held many back, given the widely reported use of simulation games for teaching operations and supply chain management.

There are also implications for staff that need to be considered when using simulation games. First, there is the training needed for associated staff or tutors, as indicated by Loon et al. (2015: 234) among others. Furthermore, teaching staff must be well prepared, able to answer questions and reassure students who become frustrated with technical difficulties, as Pasin and Giroux (2011: 1246) mention. When simulation games are played during class time, they may seem to consume an excessive amount of time compared with other teaching methods. However, if they are used outside of class time, then teaching staff will have to devote a considerable amount of time to manage the simulation, answer questions and provide feedback. Another issue for staff to be aware of is that students do not always appreciate alternative teaching methods. Aamer and El-Zine (2019: 953) draw attention to this in the context of the flipped classroom. One prominent point is that students (in their description, students talking about other students) are not always prepared for discussion and tutorials. This decreases the effectiveness of teaching activities, also so for simulation games. Hence, teaching staff need to stimulate students to engage with materials but also need to factor in the training of associated staff such as tutors, in addition to reserving time for development and resolving ‘technical’ or administrative difficulties.

## Integration into Pedagogy for Operations and Supply Chain Management

There are different approaches as to how simulation games are embedded in pedagogy for operations and supply chain management, ranging from demonstrating concepts taught in lectures to incorporation into flipped teaching. In this spirit, Pasin and Giroux (2011: 1251) present their approach as being traditional lecturing on materials requirement planning (commonly known as MRP-I) and manufacturing resources planning (aka MRP-II) with students taking an exam before a simulation game; the latter then reinforces the learning and results in students gaining a better understanding of both concepts. Also, Chakravorty and Verhoeven (1996) describe a simulation game they used for demonstrating the theory of constraints, following lectures to students on this subject matter. Another approach to using simulation games is flipped teaching in which students learn through independent study and experience before having contact with teaching staff. A case in point is Asef-Vaziri (2015: 75) who describes flipped teaching on operations management. Again, web-based simulation games appear after independent study by students and classroom teaching. Also, a quiz is used here, albeit before class attendance. In this respect, Prashar (2015: 132) points to flipped teaching only being possible when students have developed an interest in the subject matter; hence, once a foundation is built through face-to-face teaching then this mode of teaching becomes possible. On reflection, this remark extends to developing an understanding of fundamental concepts for operations and supply chain management. Though flipped teaching has been of greater interest, simulation games seem to be best placed once foundations and key concepts have been addressed in face-to-face teaching (whether online or not), so that the games reinforce deep-learning and practical skills related to operations and supply chain management.

One of the most prominent choices is whether a simulation game should be web-based or physical delivery. An example of a web-based simulation game is as previously mentioned Littlefield Technologies, used by Snider and Balakrishnan (2013) among others. Physical games are the Beer Simulation Game in its original version and the eight games mentioned by Ammar and Wright (1999). Primarily, choices for simulation games are based on how they fit with learning objectives for teaching operations and supply chain management. However, physical simulation games offer advantages in terms of sensory experience, as indicated in Osborne and Wittrock’s (1983: 493) model for generative learning, which also expands the possibilities for teaching transferable skills such as teamwork and communication. The latter point is addressed in some other studies, for example, Riley et al. (2017: 195) point to team interaction and previous software experience as factors that determined comprehension based on a survey of students have both online and face-to-face experience with a simulation game in operations management. Riley et al. (2017: 195) also point out that online delivery of a simulation game does not lead to students’ appreciating teamwork. Nevertheless, it depends on the design of the teaching plan how simulation games are used and how effective they are towards learning objectives. A case in point is Dekkers et al. (1998) who report on a business simulation game that was complemented by sessions about teamwork and presentation skills. In their approach, teams of students when running out of cash had to present their case for additional loans to a ‘bank manager’ supported by a ‘financial advisor’, who could refuse or (partially) grant the application. At the end of this game students had to present their annual report to ‘shareholders’ in a cafeteria setting, simulating a common practice for smaller firms; the annual report and presentation formed part of the assessment. Whereas web-based or physical delivery may be influenced by availability of funding, resources and ease-of-use, the choice is primarily pedagogic and there are workarounds so that social skill development can also be embedded in web-based delivery; however, in principle, web-based simulation games reduce sensory information, and may therefore unintentionally reduce cognitive learning and the development of social skills.

Another fundamental consideration for integration is the so-called post-game analysis or discussion. Onofrei and Stephens (2014: 62–63) draw attention to this related to their use of the Beer Simulation Game. By relating the process and outcomes of a simulation game to the concepts of the teaching, such analysis or discussion results in better understanding. In their case, Onofrei and Stephens (2014: 63) highlight the value of group discussions. Snider and Balakrishnan (2013: 157) appear to do the same. Salas et al. (2009: 565) refer to post-game discussion as feedback but this seems to be more driven by teaching staff rather than active learning by students. Notwithstanding how the post-game analysis is delivered, the importance of post-game analysis or discussion also resides in a simulation game being a specific set-up, i.e. akin to a case study. Based on Dekkers and Hicks (2019)[[1]](https://word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-GB&rs=en-US&hid=4nKBdHxrjU62CC8NZ0r1gw.0.0&wopisrc=https%3A%2F%2Fwopi.onedrive.com%2Fwopi%2Ffiles%2F1CD663E42409E565!114&wdlor=c52FBB514-4634-48E5-B8E2-6AFE9B150E65&wdo=2&wde=docx&sc=host%3D%26qt%3DDefault&wdp=3&uih=onedrivecom&jsapi=1&jsapiver=v2&corrid=f77dd637-b988-4751-b11c-70216cc19e7b&usid=f77dd637-b988-4751-b11c-70216cc19e7b&newsession=1&sftc=1&uihit=editaspx&muv=1&cac=1&sfp=1&hch=1&hwfh=1&dchat=1&wdorigin=Other&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush#_ftn1), case studies require understanding context and their specific settings. In the case of simulation games, this could be to which extent the use of methods, conceptualisations and theories could apply to other settings, for example, industries and modes of operation. Also, consideration of alternative explanations, including methods, conceptualisation and theories will enhance learning against the backdrop of abductive reasoning (for the latter, see Dekkers [2017: 61–63]). This could take the form of presentations as in the case of Onofrei and Stephens (2014: 62) or perhaps a summative assessment such as a report, which Asef-Vaziri (2015: 86) used and Snider and Balakrishnan (2013: 156–157) intimate. In this perspective, Vos (2015) shows the diverse ways in which learning by students is assessed in simulation games for business and marketing education. From her data (Vos, 2015: 68–69) it can be inferred that educators typically use both formative and summative assessments for a simulation game. Also, attendance (Vos, 2015: 70) is seen as the dominant inhibitor for performance. Thus, post-game analysis or discussion, in whatever form, or using both formative and summative assessments, plays a key role in active learning with simulation games.

Another point that emerges from some studies is that providing simulation games for different levels of study, or even practitioners, may lead to changes in emphasis. Both Miyaoka (2005: 82) and Snider and Balakrishnan (2013: 160–161) bring to the fore that when implementing web-based operations management simulations, taught postgraduate students tend to conduct quantitative analyses. They also find that undergraduate students rely more on experimentation and gravitate towards qualitative approaches. Chuang (2020: 273) concurs with this position and adds that undergraduate students may have limited experience. In this sense, all three studies taught MBA students as a specific group of postgraduate students. Moreover, this outcome likely depends on what and how it was taught before conducting a simulation game. Another group for teaching is practitioners. Simulation games for these groups are reported by Haapasalo and Hyvönen (2001), Pourabdollahian et al. (2012), and van der Zee and Slomp (2009). Whereas students need to gain experience in operations and supply chain management, practitioners will look for what they can apply to their own situation. This not only influences how realistic such a simulation game must be but also how the post-game analysis connects with practice. Nevertheless, it may be useful to consider which students are taught – undergraduate, postgraduate taught students or practitioners – the learning processes and how they interact with simulation games.

A final factor for the delivery of simulation games is the spread and times of activities related to the game itself. This is mostly related to how students allocate and distribute their time to the simulation game and all its related activities. For example, Chuang (2020: 273) tells that longer duration, probably meaning spread over a longer period, tend to lead to worsening performance by students. She therefore suggests concentrating activities for games into shorter periods. Another phenomenon with regard to timing is reported by Miyaoka (2005: 81), and Snider and Balakrishnan (2013: 156) for the web-based simulation game Littlefield Technologies. Both state that students must be stimulated to engage early on with the spirit of the simulation game; it seems that some teams followed a hands-off approach leading to less leeway for improving their performance later. Moreover, Roeder and Miyaoka (2015: 3488) report that not all students felt engaged with this web-based simulation game, potentially leading to discontent in some groups of students. Similarly, in Aamer and El-Zine’s (2019: 953) study indications of lesser engagement and being unprepared are found in the cited comments by students. These points correspond with Prashar’s (2015: 132) notion that students struggle more with unstructured classrooms on operations management, particularly for introductory teachings. In the same spirit, Asef-Vaziri (2015: 80) reports being unsuccessful in managing that all students attending discussions were prepared in the flipped classroom. Thus, particularly for web-based simulation games, structuring activities will be helpful for fully engaging students, and measures should be sought to ensure students are prepared for active learning in its many manifestations during simulation games for operations and supply chain management.

In addition to advantages and disadvantages mostly discussed from a student perspective, there are also studies that raise concerns. For example, Rogmans and Abaza (2019: 402) found that student engagement was stronger during a traditional case-study class than during simulation games; however, they do not provide an explanation. They also mention another study, namely Tanner et al. (2012: 122), in which faculty members that were surveyed were somewhat hesitant to declare that simulation games were more effective than other teaching methods with engagement by students. Both indicate that the design of pedagogy deserves attention while keeping in mind that there are also other forms of teaching that may lead to generative learning and increased levels of student engagement.

# QpQ SIMULATION GAME

The QpQ Simulation Game is a non-computerised (manual paperwork) production game, which mimics a car factory, which serves multiple learning aims in the context of operations management. It is a further development of the LIRA Simulation Game developed at Delft University of Technology at the end of the 1990s (Dekkers et al., 1998). First, it aims at familiarising students with basic concepts of operations management, such as order processing, production planning, capacity management, supply chains, quality control and efficiency of processes. Second, it supports students understanding the impact of manufacturing planning and control techniques, for instance make-to-order (MTO), just-in-time (JIT) production and enterprise resource planning (ERP). Furthermore, it assists them in enhancing their problem-solving skills by applying methods and modelling from systems thinking, a transferable skill set. In this sense, the QpQ Simulation Game resembles the actual processing of orders in a company and the production of its goods, though in a simplified manner. The simulation game is based on recurrent processes that do cope less well with variety and have difficulty in achieving optimal performance. It requires analysis of the current situation in a first round against (future) requirements. Such analysis should identify the root causes to be addressed. The impact of these improvements can be checked by students when playing a successive round of the simulation game. The QpQ company, rounds and options and other relevant information of the game follow now.

## QpQ Company: Set-up of Simulation Game

The fictive company, called QpQ, delivers cars consisting of four standard types to customers: Family, Pony, Sedan and Ayrton. For these four basic cars, four options are available: engine type (diesel, electric or petrol); headlights (standard or xenon); GPS and seats (black, white or blue). These basic types and the options result in a product range of more than 200 different cars that can be delivered to customers. In addition to the basic types of car, the product range also includes two ‘specials’ (utility vehicles): the coastguard truck and the light repair truck. For an impression of the cars to be produced see Figure 10.1.



*Figure 10.1 Cars produced by the QpQ company*

The organisational structure of the QpQ company consists of four departments and a manager. The departments are Sales, Logistics, Production and Financial Administration. The Logistics Department is divided into Production Planning and Goods Receipt (Warehouse), and the Manufacturing department consists of Production and Quality Assurance. In addition to the four departments, there are the supplier of parts, the AYN Employment Agency, and the YGWYS Consultancy Firm. Though these three are considered as external to the company, their players are part of the game. The AYN Employment Agency provides a flexible workforce that can be called in by the manager. The YGWYS Consultancy Firm observes the working and performance of the company during the rounds but does not participate in work for orders and neither does it intervene in any way; however, they can provide advice to the manager of the QpQ company between rounds depending on whether it is desired. In particular, the employment agency complements the four departments with additional labour and the consultancy firm is at hand for advice.

*Table 10.1 Typical roles and number of players*

|  |  |  |
| --- | --- | --- |
| **Player** | **Role** | **No. players** |
| Financial Administration | Bookkeeping of QpQ company (profit/loss) | 1 |
| Goods Receipt (Warehouse) | Checking quantity of incoming goods from supplier | 1-2 |
| Manager | Overseeing order processing, corrective actions for quality, delivery of orders to customer, allocation of (flexible) workforce | 1 |
| Production | Manufacturing of cars | 2-4 |
| Production Planning | Providing picklists to supplier based on Bill of Materials | 1-3 |
| Quality Assurance | Checking car before delivery to customer | 1-2 |
| Sales | Receiving orders from customer, record details of order for further processing | 1-2 |
| Shop Floor Control | Issuing complete jobs to production | 1 |
| **Subtotal (QPQ)** |  | **9-16** |
| AYN Employment Agency | Providing flexible workforce to QpQ company | 0-1 |
| Supplier | Supplying materials to QpQ | 2-3 |
| YSWYG Consultancy | Advising manager of QpQ company on improvements | 0-2 |
| **Total** |  | **11-22** |

Whereas there is a minimum number of players needed to run the simulation game, the actual distribution of players is up to the learning objectives for the game. Table 10.1 displays the numbers of players as well as the typical roles of the departments and players. It should be noted that this table is based on roles during the trial and the first round of the game. For subsequent rounds, players can suggest changes in roles, depending on how they want to improve the QpQ company’s operations. However, some roles are not affected by improvements. For example, in all rounds and scenarios, players in the Sales Department receive and register the order, ‘negotiate’ a contract and pass on the necessary documentation to the next stage of order processing.



*Figure 10.2 Order used during QpQ Simulation Game*

The game consists of a trial run and two to three rounds, depending on the learning objectives and time available to play the game. The number of rounds also depends on how quickly in successive rounds players identify those solutions that yield a better performance. During the trial run only three orders are issued by the customer (teaching staff or tutor) to the QpQ company; Figure 10.2 illustrates an example of an order. The purpose of the trial run is that students familiar themselves with the roles they are fulfilling, including the processes and forms to be used. It is the intention that the group produces at least two out of three orders to understand all processes and forms. The trial run can last between 30 and 40 minutes, since students have less experience with these types of processes. During the first round, there are 20 orders issued (one order every minute). Two of these orders are for two cars (a double order, making it 22 cars to be produced in 20 minutes). The next rounds also consist of the same orders. However, the difference is that players now have the possibility of introducing changes in order to improve the QpQ company’s performance. Improvements that can be implemented may be divided into two categories: (i) changes and improvements related to staffing (retraining, multi-skilled personnel, dismissal); and (ii) changes and improvements related to the processes and structures; the second category includes three scenarios that the players can choose from (MTO, ERP and JIT production).

## Three Different Scenarios

The first of these three scenarios represents the simplest form of the game; this scenario is used for the trial run and the first round. MTO is a common practice in manufacturing and it means that all activities for an order are only started when the customer’s order has been received. In the case of the QpQ Simulation Game, those activities cover recording the order, preparation of documentation for logistics and production, acquisition of materials, production of the cars and delivery of the product to the customer. Generally speaking, MTO aims to give flexibility for customising the product; however, it comes along with long lead-times for customers to receive their products.

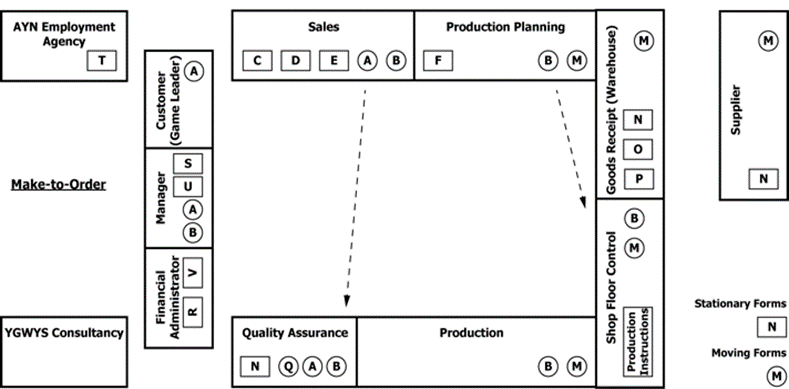
The second scenario that the players can choose from during later rounds of the game is ERP, which integrates planning and control with the company’s other functions. For the QpQ Simulation Game it means that with the use of ERP, the players can have an automated pick list that includes all the components and materials needed for production of the car; this accelerates production planning and results in higher consistency for filling out documentation. As a result of introducing ERP, the lead time for an order should be reduced, making the production process more efficient as less time will be spent on solving problems related to incorrect documentation.

Finally, the third scenario for playing the game is based on JIT production where the manufacturing of products is initiated as and when demand requires (this is part of the conceptualisation of lean production). It means that the QpQ company should have an (limited) inventory of sub-assemblies and only when a customer places an order will final assembly of the product (i.e. the car) start. Adopting this scenario reduces the preparation of logistics documentation and since all main sub-assemblies of the car are already built, it will make completion of the order less time consuming. This option is one of the improvements that teams of students can implement after the first round (which is based on MTO).

After the first round of the QpQ Simulation Game the students can opt for different scenarios with their combinations based on problem solving and decision making for generating more profit. Normally, the first round results in no – or few – cars delivered to the customer, and consequently, students are asked how they want to improve performance of the production system. The expenditures for implementing improvements are also limited by cash flow, i.e. losses in the first round reduce working capital in hand. So, students can develop their own solutions which are set off against the options available to make them feasible to implement within the time frame of the simulation games. Also, students can combine scenarios. For example, implementing only the scenario of ERP implies retention of the MTO scenario. And the scenario of JIT production can be played in combination with the scenario of ERP. Consequently, improvements for later rounds should result from analysis, considering alternatives and application of conceptualisations taught during operations management provisions.

## Delivery and Evaluation of the QpQ Simulation Game

Using these three different scenarios, the QpQ Simulation Game was delivered and tested in three different settings with three different groups of students. Before each delivery, a brief introduction to the game was given. In the case of the first delivery, since the simulation game was delivered as part of a postgraduate course in business and management, the students also had the opportunity to attend lectures and tutorials related to systems thinking and decision-making processes, based on a textbook about systems thinking (Dekkers, 2015). The students were advised to think and make decisions on how they could use basic concepts from operations management for improving the productivity of manufacturing and the company in total, rather than focusing solely on producing a high quantity of cars. The simulation game was played twice to see if students’ performance would improve (only in the second delivery the simulation game was played for three rounds after student requests). A trial run, lasting 10 minutes, was played to familiarise students with the game and assist them to make decisions as to how they were going to distribute their workforce among the different departments. Following on, two runs (each lasting 20 minutes) were played with a break of 45 minutes in between. During the break, staff and tutors set up the game and students had brief discussions within their teams to decide any changes that would improve their performance. To assess the students’ performance as well as the potential of the game, the outcomes from each run were carefully recorded together with comments from participants. The three different deliveries and their outcomes are described below.



*Figure 10.3 Layout for MTO (make-to-order), including forms to be used by players*

### First delivery of QPQ Simulation Game

The first delivery of the QpQ Simulation Game was to sixteen tutorial groups composed of students of a postgraduate course at the Adam Smith Business School (University of Glasgow). At the time, only the MTO scenario was available to the students together with improvements related to staffing. Figure 10.3 illustrates the typical layout of the QpQ Company using this scenario. In the first round, most groups produced between one to two cars, however, most of these failed to pass the quality assurance step before delivery, and therefore, no cars were delivered to the customer (tutor). In the second round, after rearrangements in the layout of the game and position of players, the QpQ company’s productivity was slightly increased with mostly one to two cars being delivered to the customer, and a few more being ‘stuck’ in production or quality assurance. In most groups, however, the bottleneck was identified to be the supplier and goods receipts as most of the orders did not make it to shop floor control to be issued as production orders.

Feedback from students regarding the game was drawn from the evaluation of the course in which it was embedded. As a starting point, the purpose seemed to be clear to all students who participated in the game as none of them reported any misunderstanding of why they were playing the game or similar statements in the evaluation. In addition, many students recognised the game as a positive aspect of the course and none of them considered it negatively. To be more specific, terms such as ‘interesting’, ‘engaged’, ‘novel’, ‘involvement’, ‘creative’, ‘practical’ and ‘stimulated’ were used to describe the game. Also, there were students who pointed out that the game had enhanced their understanding of the basic concepts of management that had been taught in the course. Moreover, feedback also showed that the game had a clear link with practical problems and how to solve them. As quoted from one student, ‘Lego game … better understanding of business problems, decision making and system thinking’. Overall, the game provided added value to the traditional style of lecturing and tutorials. For example, when asked how this class can be improved a student stated:

*More workshops and game simulation. These stimulate our thinking better than sitting in lecture for 2–3 hours.*

Because this was the first delivery of the game, some points for improvement had been indicated by the students. One thing worth noting is that students thought the material provided for instruction of the game lacked clarity at some points, which created some difficulties for their understanding of the running of the game. This raised the point that since the game was designed to reflect actual processes in a company, it is the complexity of business processes and their lack of experience with these that students reported. Notwithstanding this, the feedback from the students motivated the delivery team to make further improvements to the game; these were implemented in the next two deliveries.

### Second delivery of QpQ Simulation Game

The game was delivered for a second time to a group composed of students from a postgraduate course and MBA course at the Business School of Newcastle University. These students had knowledge about the basic principles of operations management but none of them had studied systems theory before participating in the QPQ Simulation Game. In this delivery, having considered feedback from students during the first delivery of the game and with the aim of improving the student experience and introducing more concepts of operations management, the QpQ Simulation Game went through a few changes. First, instructions were developed for the roles and responsibilities of each department and distributed to the students before each round. Second, the JIT and ERP scenarios were developed. In the first round, students delivered five cars to the customer. Similar to the first delivery of the game, many orders were piled up in the supplier and goods receipt. In the second round, students chose to adopt the ERP scenario and that resulted in producing and delivering seven cars to the customer. In response to students’ request, a third round was played. This time the JIT scenario was selected and the QpQ company’s productivity was greatly increased with delivery of 14 cars to the customer. However, the company failed to satisfy the customer fully, nor did it make a profit. The main reason behind that was that the delivery of the orders that were issued first, started after 15 minutes in the game. Although students had identified a pattern that would make them process the orders more efficiently, this took them time and as a result they did not manage to complete all the orders in time. It is estimated that if the students had a few more minutes, they would possibly be able to complete all the orders given by the customer.

Evaluation of this second delivery of the game comes mainly from the teaching staff’s observations and conversations between students that participated. Similar to the previous delivery, students pointed out that the game had contributed to understanding the complexity of order processes in companies and the usefulness of systems thinking when facing operational problems. However, it was also noted that students felt that applying systems thinking during the game was not an easy task due to time constraints and pressure to perform. In terms of the additional options available, it was observed by staff that the students were excited about the flow of the game and their performance on processing orders when implementing JIT production. Nevertheless, the students were disappointed when they realised that they still had not managed to make a profit by the end of the game. Thus, the second delivery of the QpQ Simulation Game provided the students with an enhanced experience through additional options available but there still remained some dissatisfaction about not fully succeeding in meeting performance objectives.

With more alternatives, provision of instructions and better design of the assembly instructions, students showed greater engagement in the game. A positive aspect is that they were asking for an additional round after the scheduled two rounds and commented that this game should be included in regular provision of their degree. Consequently, it is noted that improvements in the game had been successful and improved the student experience, but further development that could help students meet the break-even point for profit and ‘taste a bit of winning’ in the game should also be considered.

### Third delivery of QpQ Simulation Game

From the previous two deliveries, it had become apparent that one of the drawbacks was the amount of documentation that had to be produced by players (e.g., order forms, bill of materials, pick lists). One solution to that would be to partly digitise the process of filling out documentation used during the game, with the aim of helping students to produce more efficient and accurate reports at the end of the game. After discussions with colleagues from the School of Computing it appeared that the QpQ Simulation Game fitted well with projects for their third-year undergraduate students. The delivery team had several meetings with two groups of students from the School of Computing and it was agreed that two versions of software would be designed. The students delivered the final versions of the software when the third delivery of the QpQ Simulation Game took place in order to test the improvements made through the software (Figure 10.4). This time, the group playing the game was composed mainly of undergraduate students from the School of Computing and some undergraduate students from the Adam Smith Business School of the University of Glasgow. Students from the Business School had studied principles of operations management, such as JIT production and MTO, whereas students from the School of Computing had no prior experience with operations management. In this delivery, the usual trial round was played, but due to time constraints and the reason that the main aim was to test the software, the other two rounds lasted ten minutes each. The students did not manage to deliver a car in the first round although three cars were at the production stage when the time was up. In the second round, the students produced one car that was accepted by the customer and had several cars in production and quality assurance departments. Nevertheless, it was very interesting to observe and record the experience of the students playing the game being students from the School of Computing, the majority of whom had minimum knowledge of systems thinking, and business processes or operations management processes in general.



*Figure 10.4 Delivery of the QpQ Simulation Game*

For this third delivery of the game, the delivery team had designed evaluation forms that were filled out by the students at the end of the game. Considering the background of the students in this delivery, the first thing recognised is that the game had helped them to understand the management processes better, especially aided by the ‘physical layout’ of an organisation. The interesting feedback from this delivery was that this game enhanced the skills related to teamwork, communication, decision making, problem solving and time management.

It was also noted by some students that the relationship between each individual and the whole system was made clear to them; if someone made a mistake, the performance of the whole process would be affected. In the words of a student:

*It helped me enhance my team-working skills since I had to share the production planning post with another student and we had to work as a team.*

By contrast, some students reported on a few drawbacks they experienced while playing the game. One of the issues regarding skills development is that the game somehow restricted thinking and decision making. From this perspective, a student commented that ‘I did not have to make decisions, however, it has highlighted the importance of following instructions’, which is not the original purpose of the game. Points have also been made about lack of comprehensive understanding when being allocated to only one department and that the ‘tension’ of the game decreased the chance of interaction within the team, which was also the reason needed for the digitised solutions. This is reflected in the following comment from a student:

*I feel students are too involved in the game itself to be able to figure out the solution … did not give a very holistic understanding since I only took part in one stage.*

To sum up, this application was mainly for testing the feasibility of embedding a computer system in the game, however, neither should the points of improvement by students from the School of Computing be ignored, as they provide insights for new directions for the development team.

## Main Points to Take-Away

It is evident that students enjoyed the game, and acknowledged the positive learning experience and the opportunity to develop a deeper understanding of the concepts that were taught in lectures. In cases where students did not have a business and management background, the game proved to be beneficial in understanding the management processes of an organisation and they suggested that they would like to see similar simulation games within the context of their studies. Hence, although in general motivation for students to participate in problem-based learning activities is a challenge, our experience of playing the game demonstrates that the integration of problem-based learning into a simulation game can highly motivate students to engage in the learning process.

The QpQ Simulation Game is one of few games designed for teaching purposes that capture the primary processes of a manufacturing company and allows illustrating many concepts of operations management in a physical setting. In this sense, it offers a complete learning experience to students, from order receipt to delivery of products. In addition, students were given, albeit implicitly, a major ‘problem’ (i.e. the layout and inefficiency of MTO), but they were also facing smaller, different ‘problems’ while playing the game (e.g., distribution of the workforce across departments and teamwork). By attempting to solve these problems, students would gain more knowledge on both concepts taught in the lectures and soft skills that can be applied in practice through problem-based learning. Finally, because the game covers many operations management aspects and concepts, that makes it a powerful tool for evaluating students’ knowledge and performance and can be used at the end of a semester as an alternative to traditional assessment methods (e.g., end of course exams).

Outcomes from the three deliveries indicate that improvements made in the second delivery aided students to clearly understand and learn the differences between three types of production methods as well as to experience challenges of a real-life based manufacturing organisation. The improvements concern JIT production, which is principally a variant of assemble-to-order, and ERP. Also, the addition of software proves to be beneficial for smoother running of the game and for better production of reports. However, for the latter, better conclusions might be drawn when the game is tested for its full duration (20 minutes per round) and within a group of business and management students that have been taught about operations management and systems thinking. This indicated the need to develop simulation games, as they are hardly a one-off to develop, but it also reflected an approach to getting the core of the QpQ Simulation Game right before putting time into extending scenarios and options for playing the game.

Student feedback from the three deliveries of the game has been very positive. One positive aspect of the game is that it has managed to offer students understanding of the realities for managing production systems, as other studies already suggested. Moreover, since the QpQ Simulation Game is mainly paper based, it also shows a promising potential of increasing the interaction between students, and certain benefits of developing relevant practical skill sets for their future development, as also noted by Costantino et al. (2012: 10); this extends to transferable skills such as problem solving and working in teams. According to the comments by students, the QpQ Simulation Game also was useful in supporting students to gain a clearer understanding of the theories, concepts, methods and tools taught in the lectures. In another note, students found the game to be fun and pleasant to play, which corresponds with requests for more rounds to be played in all deliveries. Last, similar to the studies of Farrell (2005: 85) and Li et al. (2007: 32), our findings suggest that simulation games like this one can provide a richer and more compelling educational experience for students. Thus, deliveries of the QpQ Simulation Game provided broad-ranging benefits to students such as understanding the complexity of production systems, gaining soft and transferable skills, and offering an engaging and stimulating learning environment.

However, it also became apparent after the three deliveries that there is still room for improvement in the development of the QpQ Simulation Game. One of the issues is that student engagement decreased if they did not manage to meet the target number of cars that would make the ‘company’ profitable. Although the original setup of the game is to increase the chances of not meeting performance requirements so that students need to resolve problems, the effect of the alternative designs of the production system and other improvements should be more significant to keep students engaged. A further improvement to work on is providing pathways for students to gain an overview of the whole game; in the current version of the game it is possible that if a student remains in only one departement for the whole duration of the game, it is likely that they may lose comprehensive understanding of the problem. A final improvement that emerged is that some documentation needs to be revisited for reasons of both consistency and clarity for participants. This means that although development of this simulation game may have achieved its initial learning objectives, further evaluation and optimisation of its design and documentation is necessary.

# Key Points

* Simulation games have considerable benefits over traditional lectures and tutorials for the domains of operations and supply chain management for students’ learning. First, students can gain near real-life experience of what the domains entail. This is a substantial advantage as domains are experienced as being complex in nature. Second, simulation games are stimulating deep learning through the application of conceptualisation and methods for domains. In addition, experimental simulation games allow for comparing alternative approaches and solutions to determine effects on performance of production and supply systems. Third, games are also enhancing the learning of transferable skills in cases when there is teamwork for application of concepts, solving problems and comparing results (not all simulation games involve multiple players). Fourth, they provide a pleasant experience (some call it the ‘fun factor’). The evaluation of the QpQ Simulation Game corroborates these four points.
* Although developing simulation games or embedding existing games for teaching , there are indications in the literature that academic staff primarily decide on their use given the benefits for both cognitive and experiential learning. Furthermore, fine-tuning of games and adding features arising from evaluation call on additional efforts and resources beyond the initial development of a game. Both points raised here are also the case for the QPQ Simulation Game.
* Although both electronic and physical simulation games contribute to an improved learning experience, physical ones have as advantages that they enrich learning by sensory experiences that are less present in electronic versions and that they offer a better setting for transferable skills such as teamwork. However, physical simulation games may require more resources than electronic ones. The most dominant criterion for using simulation games is the learning by students in addition to their providing a pleasant experience.
* In the literature a broad range of simulation games for topics can be found. There are some aiming at specific topics in operations and supply chain management, such as balancing production lines. These tend to be relatively short to execute and relatively easy to fit into teaching schedules. There are also some that simulate production systems, which require more time and resources; scheduling is important so as not to lose the attention of students when games are spread over time. Particularly, web-based simulation games that are spread across delivery require the engagement of students’ attention early on.
* Simulation games should be part of a teaching plan for operations and supply chain management, that is to say they are embedded in the delivery, with flipped teaching being less favoured. The latter can be caused by the complexity of the domains of operations and supply chain management, and the students’ lack of real-life experience. In practice, this means that simulation games are best preceded by lectures and self-study. There are indications that most benefits for learning are achieved with what some call post-game analysis and discussion; students are less likely to identify core concepts for operations and supply chain management by just by participating in a simulation game.
* When integrating a simulation game in the delivery of operations and supply chain management, staff should be well-prepared for addressing questions raised by students and coping with technical difficulties. Also, training for those involved in the delivery should be considered.

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